



PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Flow Control Systems for Turbines

We, THE GARRETT CORPORATION, a Corporation organised under the Laws of the State of California, United States of America, of 9851—9951 Sepulveda Boulevard, Los Angeles 45, California, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to systems for controlling the flow of working fluid through turbines.

According to the present invention a turbine comprises a radial flow turbine wheel, a pair of ring members which are axially movable relative to one another and are coaxial with and surrounding the periphery of the turbine wheel and which have corresponding intermeshing ribs and slots which form between them the inlet nozzles to the turbine wheel, and a sensing element which is arranged in proximity to the fluid flow path through the turbine adjacent the inlet or outlet of the turbine and which has an effective length which varies by reason of thermal expansion and contraction as the temperature of the fluid flowing through the turbine varies, one end of the sensing element being fixed relative to the turbine casing and the other end being mechanically coupled to one of the ring members to control the axial spacing of the ring members and hence the area of the inlet nozzles in accordance with the sensed temperature. In one construction the sensing element is arranged in the fluid outlet from the turbine and in another construction it is arranged in the fluid inlet to the turbine. In the latter construction the sensing element preferably comprises a bimetallic member having at least one fold whereby the overall length of the member normal to the line of the fold changes in response to changes in temperature.

Preferably the turbine includes an axially aligned guide rod on which slides a guided member connected with one of the pair of ring members which is axially movable, and

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the bimetallic member is attached at one end to the end of the guide rod adjacent the ring member and extending away from the ring member, the other end of the bimetallic member being attached to the guided member.

The invention may be performed in various ways and several embodiments will now be described by way of example with reference to the accompanying drawings in which:—

Figure 1 is a cross section through part of a turbine incorporating the present invention and arranged to produce a controlled refrigeration;

Figure 2 is a cross section taken on the line 2—2 of Figure 1 showing one of the temperature responsive elements;

Figure 3 is an enlarged perspective view of a portion of the variable area nozzle device shown in Figure 1;

Figure 4 is a section through a turbine similar to that of Figure 1 and arranged to produce a controlled power output;

Figure 5 is a horizontal cross section taken on the line 5—5 of Figure 4 showing the mounting of one of the temperature responsive elements;

Figure 6 is a cross section through another turbine incorporating the invention and arranged to produce a controlled power output; and

Figure 7 is a horizontal cross section taken on the line 7—7 of Figure 6 showing the linkage used to actuate the variable area nozzle means.

Figures 1 to 3 of the drawings show a turbine used in cooling an aircraft cabin driven by compressed air bled from the compressor of the aircraft engine. When the aircraft engine is operating at a varying power output, the bleed air flow through the cooling turbine is continually controlled by a temperature responsive variable means. The temperature responsive means will operate the cooling turbine at the desired refrigeration output while utilizing a minimum amount of compressed air, thus conserving power of the aircraft engine furnishing the compressed air.

Figure 1 shows a turbine for providing cooling air to the cabin of an aircraft. The turbine comprises a housing 1, in which a turbine wheel 2 mounted on a shaft 3 is rotatably supported by a bearing 4. Located at the periphery of the wheel 2 is an inlet plenum 5, which is supplied with compressed air bled from the compressor of the engine of the aircraft. Mounted within the plenum 5 there is a series of temperature responsive bimetallic elements 6. Each bimetallic element 6 is fabricated from individual sections of two laminated metallic strips 6a and 6b the material of the strip 6a having a larger coefficient of thermal expansion than that of the strip 6b. Each bimetallic element 6 is constructed in a corrugated form from a number of individual sections of the two strips 6a and 6b with the strip 6a, which has the larger coefficient of thermal expansion, placed on the outside of each fold as shown in Figure 1. The individual sections are joined together to form a complete element by any desired means such as welding.

The turbine is provided with a variable area nozzle 31 which controls the flow of compressed air from the plenum 5 to the turbine wheel 2. The variable area nozzle comprises a stationary portion 11 and a ring-shaped movable portion 7 which is supported by a series of circumferentially spaced guide rods 8 and is provided with axially projecting vane elements 9, which are interleaved or meshed with conforming elements 10 attached to the stationary portion 11. The movable portion 7 also carries projecting bosses 12, which contact stops 13, one on each of the guide rods 8, when the movable portion 7 is in the fully open position, relative to the stationary portion 11, to prevent the interleaved elements of the nozzle from shifting out of mesh with each other. The stops 13 may be adjusted by the threaded ends of the guide rods 8 which project through the wall of the plenum 5 and may be locked in position with nuts 14.

Each bimetallic element 6 has one end attached to the wall of the plenum 5 by a bolt 7a and the opposite end fixed to the movable portion 7 of a variable area nozzle.

A variation in the temperature of the compressed air as it enters the plenum 5 causes thermal stress in the bimetallic elements which then exert a force on the movable portion 7 of the variable area nozzle 31. When the temperatures of the compressed air in the plenum 5 decreases, the effective overall length of the bimetallic elements 6 will increase thus tending to close the variable area nozzle. The effective overall length of the bimetallic elements 6 will increase with a decrease in temperature due to the increase in the radius of the folds of the elements caused by the different expansion rates of the portions 6a and 6b. In effect the bimetallic elements will tend

to straighten out as the temperature decreases thus increasing the effective overall length of the elements. Fluid flow through the turbine wheel 2 is thereby reduced to correspond to the decreased temperature so as to obtain a constant refrigeration output of the turbine. When an increase in the temperature of the compressed air in the plenum 5 occurs, the effective overall length of the bimetallic elements 6 will decrease, thus opening the variable area nozzle 31. As the temperature increases, the radius of the folds in the bimetallic element will decrease thus shortening the overall length of the element. Flow through the turbine wheel 2 is thereby increased to correspond to the increase in temperature so as to obtain a constant refrigeration output of the turbine. The temperature responsive means thus proportions the flow of fluid through the variable area nozzle according to the thermal energy of the fluid at the turbine inlet.

Figure 4 shows a turbine of the same general construction as that shown in Figures 1 to 3. The turbine in Figure 4 is a power turbine arranged to produce a constant power output and the mounting of the bimetallic elements is arranged so that they close the variable nozzle 32 as the temperature in the plenum 5 increases instead of opening it as in the turbine shown in Figure 1. As in the turbine shown in Figure 1 the variable area nozzle 32 comprises a stationary portion 11 and a movable portion 17 which is supported by a series of circumferentially spaced guide rods 18. The guide rods 18 are not directly attached to the movable portion 17 but each slidably supports a coaxial sleeve 19 which is fixed to the movable portion. The end of each sleeve 19 is fixed by a rivet 20 to one end of a bimetallic element 16 the other end of which passes through a slot in the sleeve 19 and is attached to the end of the corresponding guide rod 18. Each bimetal element 16 is of a similar construction to the element 6 of the construction shown in Figure 1 and is made from laminations of two different metals, each metal having a different coefficient of expansion.

When an increase in fluid temperature occurs in the plenum 5, as shown in Figure 4, each of the bimetal elements 16 will tend to contract or shorten, thus closing the variable area nozzle 17 and reducing fluid flow through the turbine wheel 2 to obtain a constant power output. Conversely, when a decrease of fluid temperature occurs in the plenum 5, each of the bimetal elements 16 tends to straighten out or increase in overall length thus causing the variable area nozzle 17 to open and increasing fluid flow through the turbine wheel 2.

Figure 6 shows another turbine of similar general construction. In this arrangement the temperature responsive variable means includes a series of circumferentially spaced tempera-

ture responsive elements 21 which are located in the wall of the turbine exhaust duct 15 and which sense the temperature of the gases in it. Each temperature responsive element 21 consists of a conventional thermostatic or temperature sensitive variable element 22 disposed to actuate a piston 23, so that an increased temperature of the variable element 22 extends the piston 23 and a decrease in temperature permits the piston 23 to be retracted by a spring 23a connected to a bellcrank 24 one end of which is pivoted to the piston 23 by a pin 25. Each bellcrank 24 is pivoted on a pin 24a supported by ears which project radially from the turbine exhaust duct 15, and is connected at its end remote from the piston 23 to one end of a rod 27 which is slidably mounted in the wall of the plenum 5, the other end of the rod being attached to a movable portion 28 of a variable area nozzle 33. The variable area nozzle also includes a stationary portion 11 and is of the same general construction as that shown in Figures 1 and 4.

When the exhaust temperature of the turbine is reduced below a predetermined value, the temperature responsive elements 21 allow the springs 23a to retract the piston 23. The resulting movement of the bellcranks 24 is transmitted through the rods 27 to the movable portion 28 to open the variable area nozzle 33. The variable area nozzle will therefore allow an increase in fluid flow through the turbine wheel 2 to obtain a constant turbine power output.

When the inlet fluid temperature through the turbine increases, the temperature responsive elements 21 in the turbine exhaust outlet 15 will sense an increased temperature and expand, thus moving the bellcranks 24 and the rods 27 in a direction to close the movable portion 28 of the variable area nozzle relative to the stationary portion 11 thereof. Such restriction of the nozzle area will reduce the fluid flow through the turbine wheel 2 to obtain a constant turbine power output.

The temperature responsive devices 21 may be used in cooling turbines when the devices will be arranged to move the variable area nozzle toward a closed position when the turbine inlet temperature decreases, in order to maintain the turbine exhaust at a constant

temperature.

WHAT WE CLAIM IS:—

1. A turbine comprising a radial flow turbine wheel, a pair of ring members which are axially movable relative to one another and are coaxial with and surrounding the periphery of the turbine wheel and which have corresponding intermeshing ribs and slots which form between them the inlet nozzles to the turbine wheel, and a sensing element which is arranged in proximity to the fluid flow path through the turbine adjacent the inlet or outlet of the turbine and which has an effective length which varies by reason of thermal expansion and contraction as the temperature of the fluid flowing through the turbine varies, one end of the sensing element being fixed relative to the turbine casing and the other end being mechanically coupled to one of the ring members to control the axial spacing of the ring members and hence the area of the inlet nozzles in accordance with the sensed temperature.

2. A turbine as claimed in Claim 1 in which the sensing element is arranged in the fluid outlet from the turbine.

3. A turbine as claimed in Claim 1 in which the sensing element is arranged in the fluid inlet to the turbine.

4. A turbine as claimed in Claim 3 in which the sensing element comprises a bimetallic member having at least one fold whereby the overall length of the member normal to the line of the fold changes in response to changes in temperature.

5. A turbine as claimed in Claim 4 including an axially aligned guide rod on which slides a guided member connected with one of the pair of ring members which is axially movable, the bimetallic member being attached at one end to the end of the guide rod adjacent the ring member and extending away from the ring member, the other end of the bimetallic member being attached to the guided member.

6. A turbine substantially as described with reference to Figures 1 to 3 or Figures 4 and 5 or Figures 6 and 7 of the accompanying drawings.

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